# Hydrodynamic modelling of seaweed zygotes attachment/detachment on a rocky substrate

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## INTRODUCTION

Settlement is the most critical period in seaweed life history. Indeed, during this period, seaweed zygotes have to reach a suitable substrate and attach on it. Few things are actually known about the processes governing attachment and detachment of these zygotes, particularly in turbulent wave-driven coastal waters. Our purpose in this project is to elaborate a numerical model of seaweed eggs' behavior near and within the viscous boundary sublayer near the substrate.

## ECOLOGY

Figure 1: *Durvillaea*, one of the species we are interested in, can be found on rocky shores on exposed coasts.

Figure 2: DICM picture by David I. Taylor. *Durvillaea* fertilized eggs are $30\mu m$ of diameter cells surrounded by a very thin layer of mucous.

After fertilization, seaweed eggs have to reach a suitable substrate and attach. Zygotes are surrounded by a very thin layer of mucous, that allows them to stick on the rocks. Once they have managed to attain and to stick on the substrate, fertilized seaweed eggs are still vulnerable for a few hours. Indeed, if the forces exerted by the sea on these propagules are strong enough, they can be removed from the rocks, except if they had enough time to anchor definitively thanks to the production of two rhizoids.

## MODELLING

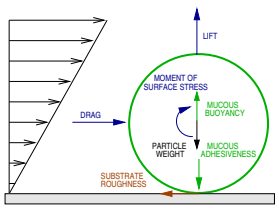


Figure 3: Seaweed zygotes are modelled as spherical solid particles surrounded by a thin layer of a viscous and sticky fluid.

The attachment and detachment processes take place in the viscous sublayer near the substrate.
The motion of eggs is governed essentially by hydrodynamic forces.
For the detachment problem, the behavior of the mucous is of special interest. Once the particle is stuck on the substrate, the mucous slides along its membrane to form a heap linking the propagule and the substrate.
Assuming that the mucous and the propagule remain together, the properties of the mucous and the roughness of the substrate must be two key parameters in the detachment process.

## NUMERICAL MODELLING

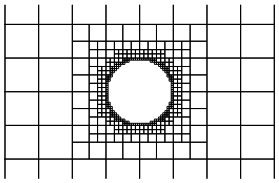

Figure 4: The Gerris Flow Solver use an quadtree/octree spatial discretisation with automatic and dynamic local refinement, which will allow us to follow moving particles.

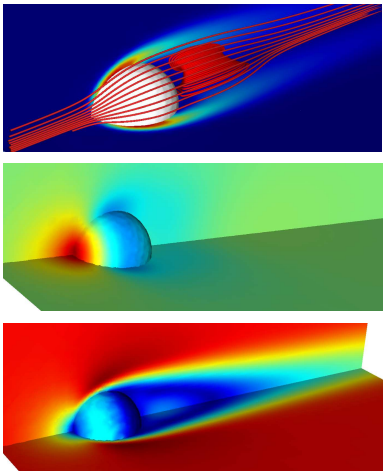

Figure 5: Simulation of the flow around a half sphere stuck on a wall for a Reynolds number of 75. From top to bottom: vorticity field + streamlines, pressure field and velocity field.

The model is made using the computational fluid dynamics software Gerris. The Gerris Flow Solver is an open source code that solves the full 3D Navier-Stokes equations (http://gfs.sf.net).
One of Gerris' strong point for this project is that it uses an quadtree/octree-based spatial discretisation mesh with adaptive refinement. The adaptive property of the mesh allows us to have a mesh that follows the propagule and that is more refined where important things are happening.
Only static solid boundaries or objects are implemented in Gerris, implementation of moving objects is something that has to be done.
Concerning the mucous, Gerris is already able to deal with two-phases flows. The major part of the work is the modelling of the adhesiveness of the mucous.

## CONCLUSION

This project is a cross-disciplinary work. It will lead to:

- determine the key parameters that allow zygotes to cross the viscous sublayer and reach the substrate
- a better understanding and modelling of the adhesiveness of the mucous
- determine the effect of substrate roughness on the attachment and detachment processes
- determine the proportion of algal zygotes that attach successfully on a substrate for a given flow
- a fluid/structure interactions module in the Gerris Flow Solver
- the proof of the efficiency of quadtree/octree adaptive refinement to deal with deformable interfaces problems

## ACKNOWLEDGMENTS

Thanks to David Taylor for the picture of the eggs and introducing me to the world of seaweeds.
This Ph.D. is funded by the Marsden Fund of the Royal Society of New Zealand.